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ABSTRACT

As part of a longitudinal study of the New York State Experimental Prekindergarten Program (PreK), several measures were administered to the four-year-old children in the fall of 1975 and to a sample of the same children in the spring of 1976. Analyses of covariance were carried out on three measures of cognitive development with one of five background characteristic variables used as covariate in each analysis. A significant positive effect of the prekindergarten program was found for two of the measures, the Cooperative Preschool Inventory and the Walker Readiness Test. With one exception, the PreK effect was significant over all levels of the control variables; the PreK effect on Walker scores was greater for children whose mothers had less education. The three measures used in the analyses reported here were the Walker Readiness Test, a 50-item, non-verbal measure of general reasoning; the Cooperative Preschool Inventory, a 64-item measure of achievement in several areas regarded as important for success in school; and the Peabody Picture Vocabulary Test, a measure of the ability to understand spoken English. Analyses of covariance of Peabody Picture Vocabulary Test scores did not show a significant PreK effect, even in the presence of the control variables. (Author/MV)

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EFFECTS OF PREKINDERGARTEN ON THREE MEASURES OF COGNITIVE DEVELOPMENT

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EFFECTS OF PREKINDERGARTEN

ON THREE MEASURES OF COGNITIVE DEVELOPMENT

The New York State Experimental Prekindergarten Program serves approximately 5,000 four-year-old children and 1,500 three-year-old children in 52 school districts. As part of a longitudinal study of the program, several measures were administered to the four-year-old children in the fall of 1975 and to a sample of the same children in the spring of 1976. In addition, an Initial Pupil Information form was used to collect data on each child's age at time of testing, mother's education, family income, and months between pretesting and posttesting. The same data were collected on a control group made up of children who were eligible for the prekindergarten program but were not enrolled.

This report presents background characteristics on the children studied and the results of analyses of program effects on three measures of cognitive development.

THE SUBJECTS

The experimental group was made up of approximately 1,800 children enrolled in the Experimental Prekindergarten Program. The control group consisted of 87 children. Because data were not complete on some children, the numbers vary somewhat in the different analyses.

THE MEASURES

The three measures used in the analyses reported here were the Walker Readiness Test, a 50-item, non-verbal measure of general reasoning; the Cooperative

Preschool Inventory, a 64-item measure of achievement in several areas regarded as important for success in school; and the Peabody Picture Vocabulary Test, a measure of ability to understand spoken English.

BACKGROUND CHARACTERISTICS OF THE SUBJECTS

The background characteristics presented here describe children who had pretest and posttest scores on the Cooperative and also had complete Initial Pupil Information on the variables used in the analyses. A total of 1,866 children met these requirements. The group differs very little from the groups having pretest and posttest scores on the Walker or the Peabody.

The records of the children described above formed the file which was used in the analyses. The variables in the file are described in Table 1.

Table 1
Description of Variables

Variable Name	Description of Variable
AGEPRE	Age in months at the time of pretest
MOED	Years of mother's education
INCOME	Family total annual income in hundreds
MOBET	Months between pretest and posttest
PRECOOP	Pretest scores on the Cooperative Preschool Inventory
POSTCOOP	Posttest scores on the Cooperative
PREWALK	Pretest scores on the Walker Readiness Test
POSTWALK	Posttest scores on the Walker
PREPEAB	Pretest scores on the Peabody Picture Vocabulary Test
POSTPEAB	Posttest scores on the Peabody

Categorical variables and those variables which could be described adequately by a mean and standard deviation are discussed separately in the sections which follow.

Categorical Background Variables

Sex was distributed rather evenly between the Experimental Prekindergarten group (PreK group) and the control group.

Table 2
Distribution by Sex

	Control	PreK
Male	47%	51%
Female	53%	49%

Nineteen languages were represented in the PreK group and two in the control group. English was the first language of 83% of the control group and 81% of the PreK. Spanish was the first language of 17% of the control group and 13% of the PreK. Six percent of the PreK children and none of the control-group children had other languages.

Table 3
Distribution by Primary Language

	Control	PreK
English	83%	81%
Spanish	17%	13%
Other	none	6%

Race was more broadly represented in the PreK than in the control group. The PreK group had fewer Caucasians and Puerto Rican-Spanish and more Blacks than the control group. The PreK group also had small percentages of American Indian, Oriental, Indian-Spanish, and West Indian children which were not represented in the control group.

Table 4
Distribution by Race

	Control	PreK
Black	19%	35%
Caucasian	64%	50%
Puerto Rican-Spanish	17%	11%
Other (American Indian, Oriental, Indian-Spanish, West Indian)	--	4%

Previous experience in some kind of prekindergarten was more common in the PreK group than in the control group. One child in the control group spent three months in a prekindergarten setting but none of the other control children had such experience. In the PreK group, 13% of the children had some previous exposure to a prekindergarten. About 10% had more than eight months previous experience in a prekindergarten.

The distributions of Mothers' and Fathers' occupations on the Warner Scale of Occupational Status (Warner, 1960) is given in Table 5. Levels 1 through 7 correspond to the original Warner levels. The homemaker category and the no information category are additions. The scale was updated to include modern job titles.

Table 5
Distribution by Socioeconomic Status

Category	Mothers' Occupations		Fathers' Occupations	
	Control %	PreK %	Control %	PreK %
Level 1	--	.2	--	.7
Level 2	1.6	1.9	6.3	2.3
Level 3	--	.6	1.6	2.0
Level 4	--	.7	6.3	4.4
Level 5	7.8	7.1	25.0	15.5
Level 6	14.1	10.7	28.1	22.7
Level 7	3.1	7.1	9.3	12.4
Homemaker	65.6	69.1	--	.3
Unknown	7.8	2.6	23.4	39.7

The distributions for the control group are similar to the distributions for the PreK group. Mothers were most often classified as Homemakers while the second most frequent classification was Level 6 on the Warner's Scale, which includes Route Salesman, Polisher, Truck Driver, and Waitress. Fathers dominated Levels 5 and 6 and the Unknown category. Level 5 includes occupations such as Baker, Fireman, Paper Hanger, Stewardess, and Belly Dancer.

The control group and the PreK group also have similar sources of income, as shown in Table 6.

Table 6
Distribution by Source of Income

Income Source	Control %	PreK %
1 Mother	4.7	8.6
2 Father	39.1	37.2
3 Unemployment Ins./Public Assistance	35.9	32.8
4 Mother & Father	9.4	11.3
5 Mother & Unemployment Ins./Pub. Asst.	1.6	6.0
6 Father & Unemployment Ins./Pub. Asst.	4.7	2.6
7 Mother, Father & Unemployment Ins./ Pub. Asst.	4.7	1.4

Slightly more of the control children than PreK children live in families with two adults. PreK children have about the same frequency of single-adult families and relatively more multi-adult families.

Table 7
Distribution by Number of Adults in the Family Unit

Number of adults in family	Control	PreK
1	31.3	31.4
2	65.6	60.6
3 and more	3.1	8.0

Non-Categorical Background Variables

Those non-categorical variables that seemed to lend themselves to description by a mean and standard deviation are shown in Table 8.

Table 8
Means and Standard Deviations of Non-categorical Background Variables

Variable Name	Control M_c	Control SD	PreK M_e	PreK SD	Mean Differences	P $M_c = M_e$
AGEPRE	54.9	3.8	53.6	3.5	-1.3	.003
MOED	10.8	3.1	10.9	2.6	.1	.842
INCOME	$9,000	5,100	$7,000	3,400	-2,000	.001
NOSIBS	2.3	2.0	1.9	1.6	- .4	.050
NOCHLD	3.2	1.9	2.9	1.6	- .3	.114
NOROMS	6.1	2.1	5.2	1.5	- .9	.001
MOBET	4.8	1.0	5.7	0.7	.9	.001

The table shows that PreK children in relation to the control group:

1. Were about 1.3 months younger when they took the pretest.
2. Have mothers with the same number of years of schooling.
3. Receive about $2,000 less income (per year) into the household.
4. Have fewer siblings (NOSIBS).
5. Live in households containing about the same number of children (NOCHLD).
6. Live in dwellings with fewer rooms (NOROMS).
7. Had about an extra month between pretest and posttest.

ANALYSIS OF COVARIANCE FOR A PREKINDERGARTEN EFFECT

Formal analysis followed a multiple linear regression approach for hypothesis testing described by Irvine, Hick, and Horan (1976). Using this technique, a traditional analysis of covariance was conducted with tests for the plausibility of the

assumptions that linear regression is not zero in some group and that linear regression is the same in both groups. Briefly stated, the procedure generates a full model (FULL) and a restricted model (REST) which leaves out some of the information in the predictor set. The significance of the omitted information is determined by testing the difference between R-squares of the two models with the F statistic. With this technique, tests were made for treatment effects of the prekindergarten program and for the importance of covariates, such as pretest score or age at the time of testing.

To establish the models required for analysis, the following vectors were established:

Vector		Description
Y	=	Total score on the criterion
U	=	Unit vector (a vector of ones)
T	=	Treatment variable: 1 if the criterion score is for a child who received PreK; 0 otherwise.
X_c	=	Observed value of the control variable if the criterion score is for a child who was in the control group; 0 otherwise.
X_e	=	Observed value of the control variable if the criterion score is for a child who was in the experimental group; 0 otherwise.
X	=	Observed value of the control variable for all children (no subscript).

Using these vectors, the following set of hypotheses and models was established.

HYP. 1: No effect of the control variable

FULL (1) $Y = a_oU + a_1T + a_2X_c + a_3X_e$

REST (2) $Y = b_oU + b_1T$

HYP. 2: No treatment effect

FULL (2) $Y = b_oU + b_1T$

REST (50) $Y = e_oU$

HYP. 3: Regression is homogeneous

FULL (1) $Y = a_oU + a_1T + a_2X_c + a_3X_e$

REST (3) $Y = d_oU + d_1T + d_2X$

HYP. 4: No treatment effect in the presence of the control variable

FULL (3) $Y = d_oU + d_1T + d_2X$

REST (4) $Y = c_oU + c_1X$

The hypotheses are tested in a sequence determined by results obtained on the respective hypotheses. If Hypothesis 1 (Hyp. 1) is retained, the control variable can be disregarded and the analysis can proceed to Hypothesis 2. Hypothesis 2 states that the control-group mean and the PreK mean on the posttest are the same. Rejection of this hypothesis is evidence of a treatment effect. If Hypothesis 1 is rejected, Hypothesis 3 is tested. Rejection of Hypothesis 3 indicates the existence of an interaction between the control variable and treatment. Acceptance of Hypothesis 3 makes it possible to test the analysis of covariance Hypothesis 4, rejection of which is evidence of a treatment effect in the presence of the control variable. This sequence of analysis allows a treatment effect to be identified while minimizing the number of hypotheses tested.

This hypothesis-testing procedure was applied to POSTCOOP, POSTWALK, and POSTPEAB with each of five single covariates: AGEPRE, MOED, INCOME, MOBET, and the corresponding pretest (e.g., PRECOOP).

RESULTS

Cooperative Preschool Inventory

Analysis of covariance was applied to the Cooperative Preschool Inventory posttest scores (POSTCOOP) with each of five control variables: AGEPRE, MOED, INCOME, MOBET, and PRECOOP. Data on the control children and PreK children on the Cooperative Preschool Inventory are given in Table 9.

Table 9
Pretest and Posttest Data on the Cooperative Preschool Inventory

Variable Name	Control n=64		PreK n=1077		Mean Differences	P
	M_c	SD	M_e	SD		$M_c = M_e$
PRECOOP	40.5	10.9	38.0	12.2	-2.5	.108
POSTCOOP	46.8	10.8	51.6	8.9	4.8	.001

The control group had a slight, but statistically nonsignificant, advantage on the pretest (Table 9). The PreK group scored significantly higher on the posttest. The substantial size of the correlations between background variables and the Cooperative posttest scores, shown in Table 10, suggest that an analysis of covariance would provide a better estimate of the effect of the prekindergarten program than do the differences between groups reported in Table 9. An analysis of covariance was carried out on Cooperative posttest scores for each of the five background variables. Results are presented in Tables 11 through 15.

Table 10
Correlation coefficient for the control group and the PreK group for variables used in the analysis of Cooperative Preschool Inventory posttest scores.

Control / PreK	AGEPRE	MOED	INCOME	MOBET	PRECOOP	POSTCOOP
AGEPRE	1.00 / 1.00	-.06 / -.03	-.04 / .00	-.27 / -.16	.24 / .24	.29 / .15
MOED		1.00 / 1.00	.60 / .18	.45 / .09	.22 / .27	.45 / .28
INCOME			1.00 / 1.00	.19 / .01	.26 / .23	.34 / .12
MOBET				1.00 / 1.00	-.18 / .05	.09 / .10
PRECOOP					1.00 / 1.00	.56 / .72
POSTCOOP						1.00 / 1.00

The effect of being exposed to PreK, as measured by the Cooperative, is positive and ranges from as little as 3.7 points to as much as 6.2 points in the presence of different control variables. The covariance analyses were made to discount the possibility that the posttest difference is due to differences between the control group and the PreK group on one or more of the control variables. It can be said with a high degree of confidence that the prekindergarten program had a positive effect as measured by the Cooperative, regardless of:

1. the child's age at the time of the pretest;
2. the level of the mother's education;
3. the amount of time between pretest and posttest;
4. the amount of family income; or
5. the child's score on the pretest.

Table 11

Analysis of covariance for a PreK treatment effect on the Cooperative posttest (POSTCOOP) with age at the time of the pretest (AGEPRE) as a control variable.

HYP. 1: There is no linear relationship between AGEPRE and posttest score on the Cooperative (POSTCOOP).

FULL (1) $POSTCOOP = 2.7 + 27.5T + .8AGEPRE_c + .4AGEPRE_e$ $R^2=.0432$

REST (2) $POSTCOOP = 46.8 + 4.9T$ $R^2=.0151$

$F = 17$ with 2/1137 df, $P = .001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTCOOP = 2.7 + 27.5T + .8AGEPRE_c + .4AGEPRE_e$ $R^2=.0432$

REST (3) $POSTCOOP = 23.4 + 5.4T + .4AGEPRE$ $R^2=.0416$

$F = 1.9$ with 1/1137 df, $P = .17$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of AGEPRE.

FULL (3) $POSTCOOP = 23.4 + 5.4T + .4AGEPRE$ $R^2=.0416$

REST (4) $POSTCOOP = 30.2 + .4AGEPRE$ $R^2=.0230$

$F = 22$ with 1/1138 df, $P = .0001$

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTCOOP = 23.4 + 5.4T + .4AGEPRE$

Table 12

Analysis of covariance for a PreK treatment effect on the Cooperative posttest (POSTCOOP) with mother's education (MOED) as a control variable.

HYP. 1: There is no linear relationship between MOED and posttest score on the Cooperative (POSTCOOP).

FULL (1) $POSTCOOP = 29.8 + 11.1T + 1.6MOED_c + 1.0MOED_e$ $R^2=.1039$

REST (2) $POSTCOOP = 46.7 + 4.9T$ $R^2=.0151$

$F = 56$ with 2/1137 df, $P = .0001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTCOOP = 29.8 + 11.1T + 1.6MOED_c + 1.0MOED_e$ $R^2=.1039$

REST (3) $POSTCOOP = 35.6 + 4.8T + 1.0MOED$ $R^2=.1019$

$F = 2.6$ with 1/1137 df, $P = .11$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of MOED.

FULL (3) $POSTCOOP = 35.6 + 4.8T + 1.0MOED$ $R^2=.1019$

REST (4) $POSTCOOP = 40.1 + 1.0MOED$ $R^2=.0873$

$F = 19$ with 1/1138 df, $P = .0001$

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTCOOP = 35.6 + 4.8T + 1.0MOED$

Table 13

Analysis of covariance for a PreK treatment effect on the Cooperative posttest (POSTCOOP) with family income (INCOME) as a control variable.

HYP. 1: There is no linear relationship between INCOME and posttest score on the Cooperative (POSTCOOP).

FULL (1) $POSTCOOP = 40.2 + 9.1T + .07INCOME_c + .03INCOME_e$ $R^2=.0377$

REST (2) $POSTCOOP = 46.7 + 4.9T$ $R^2=.0151$

F = 13 with 1/1137 df, P = .0001

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTCOOP = 40.2 + 9.1T + .07INCOME_c + .03INCOME_e$ $R^2=.0377$

REST (3) $POSTCOOP = 43.4 + 5.6T + .04INCOME$ $R^2=.0352$

F = 2.9 with 1/1137 df, P = .09

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of INCOME.

FULL (3) $POSTCOOP = 43.4 + 5.6T + .04INCOME$ $R^2=.0352$

REST (4) $POSTCOOP = 49.0 + .03INCOME$ $R^2=.0155$

F = 23 with 1/1138 df, P = .0001

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTCOOP = 43.4 + 5.6T + .04INCOME$

Table 14

Analysis of covariance for a PreK treatment effect on the Cooperative posttest (POSTCOOP) with months between pretest and posttest (MOBET) as a control variable.

HYP. 1: There is no linear relationship between MOBET and posttest score on the Cooperative (POSTCOOP).

FULL (1) $POSTCOOP = 42.2 + 2.0T + 1.0MOBET_c + 1.3MOBET_e$ $R^2=.0244$

REST (2) $POSTCOOP = 47.8 + 4.9T$ $R^2=.0151$

$F = 5.4$ with 2/1137 df, $P = .005$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTCOOP = 42.2 + 2.0T + 1.0MOBET_c + 1.3MOBET_e$ $R^2=.0244$

REST (3) $POSTCOOP = 40.7 + 3.7T + 1.0MOBET$ $R^2=.0243$

$F = .07$ with 1/1137 df, $P = .80$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of MOBET.

FULL (3) $POSTCOOP = 40.7 + 3.7T + 1.3MOBET$ $R^2=.0243$

REST (4) $POSTCOOP = 42.3 + 1.6MOBET$ $R^2=.0162$

$F = 9.5$ with 1/1138 df, $P = .002$

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTCOOP = 40.7 + 3.7T + 1.3MOBET$

Table 15

Analysis of covariance for a PreK treatment effect on the Cooperative posttest (POSTCOOP) with the pretest (PRECOOP) as a control variable.

HYP. 1: There is no linear relationship between PRECOOP and posttest score on the Cooperative (POSTCOOP).

FULL (1) $POSTCOOP = 24.2 + 7.4T + .6PRECOOP_c + .5PRECOOP_e$ $R^2=.5057$

REST (2) $POSTCOOP = 46.8 + 4.9T$ $R^2=.0151$

$F = 564$ with 2/1137 df, $P = .001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTCOOP = 24.2 + 7.4T + .6PRECOOP_c + .5PRECOOP_e$ $R^2=.5057$

REST (3) $POSTCOOP = 25.3 + 6.2T + .5PRECOOP$ $R^2=.5056$

$F = .18$ with 1/1137 df, $P = .67$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of PRECOOP.

FULL (3) $POSTCOOP = 25.3 + 6.2T + .5PRECOOP$ $R^2=.5056$

REST (4) $POSTCOOP = 31.4 + .5PRECOOP$ $R^2=.4813$

$F = 56$ with 1/1138 df, $P = .0001$

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTCOOP = 25.3 + 6.2T + .5PRECOOP$

Walker Readiness Test

Analysis of covariance was applied to the Walker Readiness Test posttest (POSTWALK) with each of the five control variables: AGEPRE, MOED, INCOME, MOBET, and PREWALK. Data on the control children and PreK children on the Walker Readiness Test are given in Table 16.

Table 16
Pretest and Posttest Data on the Walker Readiness Test

Variable Name	Control n= 62		PreK n=1354		Mean Differences	F $M_c = M_e$
	M_c	SD	M_e	SD		
PREWALK	28.3	9.8	24.4	9.6	-3.9	.002
POSTWALK	33.3	8.3	38.4	6.8	5.1	.001

To estimate the possible influence of the background variables in each group, a matrix of simple correlations is given in Table 17. The background variables appear to be related to the Walker posttest scores (POSTWALK), suggesting that an analysis of covariance would provide a better estimate of the effect of the treatment than would the simple differences between groups reported in Table 16.

Table 17
Correlation coefficients for the control group and the PreK group for variables used in the analysis of Walker Readiness Test posttest scores.

Control / PreK	AGEPRE	MOED	INCOME	MOBET	PREWALK	POSTWALK
AGEPRE	1.00 / 1.00	-.07 / .00	-.07 / .01	-.30 / -.14	.38 / .24	.26 / .18
MOED		1.00 / 1.00	.60 / .18	.48 / .03	.02 / .16	.38 / .16
INCOME			1.00 / 1.00	.23 / .02	.08 / .16	.16 / .08
MOBET				1.00 / 1.00	-.20 / -.03	.20 / .01
PREWALK					1.00 / 1.00	.54 / .49
POSTWALK						1.00 / 1.00

The formal analysis followed the procedure and nomenclature described for the Cooperative. Results are given in Tables 18 through 22.

The traditional analysis of covariance hypothesis was retained for two of the five control variables: AGEPRE and PREWALK. For each of these variables there was a linear relationship with the posttest, and the size of the relationship was the same for both the control group and the PreK group. The within-group correlation coefficients are given in Table 17. Both control variables enhanced the PreK effect of 5.1 raw score points shown in Table 16. AGEPRE increased this estimated effect to 5.6 points. PREWALK had a much stronger effect for two reasons: 1) it showed a strong correlation with the posttest (control: r=.54, PreK: r=.49); and 2) the control group received a higher score on the pretest. The net effect is an estimated PreK effect of 6.5 raw score points on the Walker posttest.

INCOME and MOBET failed to be established as covariates. As shown in Table 17, these variables have the lowest correlations with Walker posttest scores. This is, however, an important finding. Any findings in regard to a PreK effect on the Walker posttest scores would hold for all levels of INCOME and MOBET.

The analysis using mother's education (MOED) as a control variable showed an interaction between MOED and POSTWALK, as shown in Table 19 and Figure 1. At Hypothesis 1, MOED was established as a useful control variable. But at Hypothesis 3, it was found that regression was not homogeneous. This means that MOED-POSTWALK correlation for the PreK group is different from that for the control group. These correlations are given in Table 17 as .38 for the control group and .16 for the PreK group. The analysis shows that there is an overall effect of 5.1 points regardless of mother's education. However, the effect is not general. It is larger for those children whose mothers are poorly educated and smaller or nonexistent for children of better educated mothers.

In summary, the evidence indicates that the prekindergarten program had a positive effect on Walker posttest scores. The effect was evident regardless of:

1. the child's age at the time of the pretest;
2. the amount of time between pretest and posttest;
3. the amount of family income; or
4. the child's score on the pretest.

The effect of the prekindergarten program was greater for children whose mothers had less education.

Table 18

Analysis of covariance for a PreK treatment effect on the Walker posttest (POSTWALK) with age at the time of the pretest (AGEPRE) as a control variable.

HYP. 1: There is no linear relationship between AGEPRE and posttest score on the Walker (POSTWALK).

FULL (1) $POSTWALK = 3.4 + 16T + .55AGEPRE_c + .35AGEPRE_e$ $R^2=.0632$

REST (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

$F = 20$ with 2/1114 df, $P = .0001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTWALK = 3.4 + 16T + .55AGEPRE_c + .35AGEPRE_e$ $R^2=.0632$

REST (3) $POSTWALK = 13.3 + 5.6T + .37AGEPRE$ $R^2=.0625$

$F = .77$ with 1/1114 df, $P = .3799$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of AGEPRE.

FULL (3) $POSTWALK = 13.3 + 5.6T + .37AGEPRE$ $R^2=.0625$

REST (4) $POSTWALK = 20.16 + .34AGEPRE$ $R^2=.0292$

$F = 40$ with 1/1115 df, $P = .0001$

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTWALK = 13.3 + 5.6T + .37AGEPRE$

Table 19

Analysis of covariance for a PreK treatment effect on the Walker posttest (POSTWALK) with MOED as a control variable.

HYP. 1: There is no linear relationship between MOED and posttest score on the Walker (POSTWALK).

FULL (1) $POSTWALK = 22.2 + 11.6T + 1.0MOED_c + .4MOED_e$ $R^2=.0630$

REST (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

$F = 21$ with 2/1114 df, $P = .0001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTWALK = 22.2 + 11.6T + 1.0MOED_c + .4MOED_e$ $R^2=.0630$

REST (3) $POSTWALK = 28.2 + 5.1T + .5MOED$ $R^2=.0594$

$F = 4.348$ with 1/1114 df, $P = .04$

Result is: reject the hypothesis.

(Although there is a treatment by MOED interaction, it is ordinal and can be assumed to be zero so that the following hypothesis may be tested.)

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of MOED.

FULL (3) $POSTWALK = 28.2 + 5.1T + .5MOED$ $R^2=.0594$

REST (4) $POSTWALK = 33.0 + .5MOED$ $R^2=.0315$

$F = 33$ with 1/1115 df, $P = .0001$

Result is: reject the hypothesis.

FINAL MODELS:

MODEL (1): $POSTWALK = 22.2 + 11.6T + 1.0MOED_c + .4MOED_e$

MODEL (3): $POSTWALK = 28.2 + 5.1T + .5MOED$

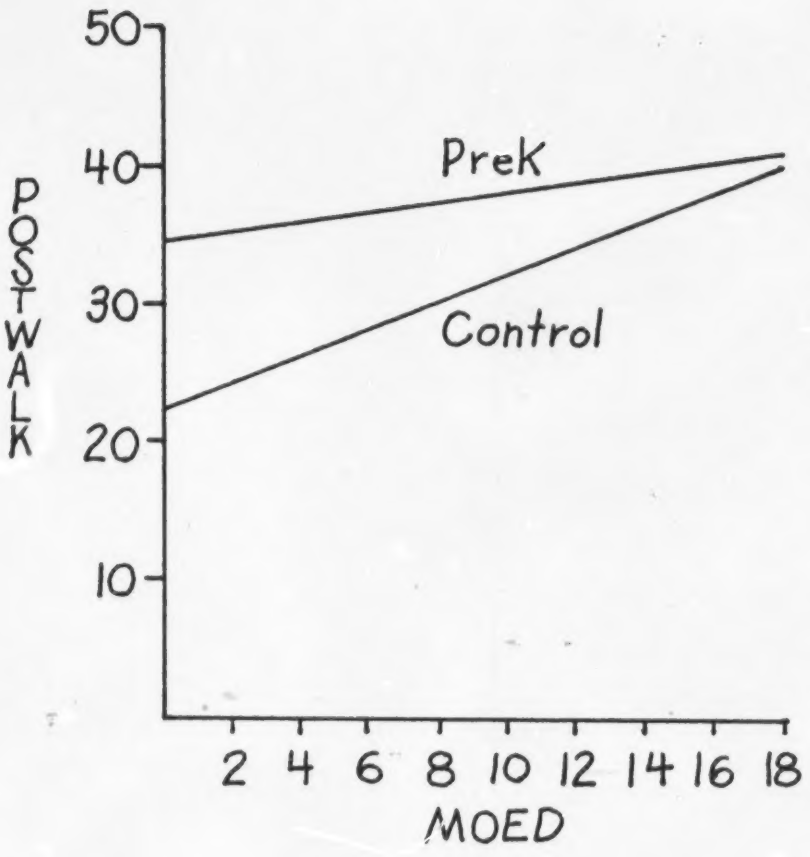

Figure 1.

Relationship between MOED and POSTWALK
(Plot of Table 19 Model 1)

Table 20

Analysis of covariance for a PreK treatment effect on the Walker posttest (POSTWALK) with family income (INCOME) as a control variable.

HYP. 1: There is no linear relationship between INCOME and posttest score on the Walker (POSTWALK).

FULL (1) $POSTWALK = 30.9 + 6.4T + .03INCOME_c + .02INCOME_e$ $R^2=.0353$

REST (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

$F = 4.2$ with 2/1114 df, $P = .0156$

Result is: retain the hypothesis.

HYP. 2: There is no PreK treatment effect.

FULL (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

REST (50) $POSTWALK = 38.1U$ $R^2=.0000$

$F = 32$ with 1/1116 df, $P = .0001$

Result is: reject the hypothesis.

FINAL MODEL (2): $POSTWALK = 33.3 + 5.1T$

Table 21

Analysis of covariance for a PreK treatment effect on the Walker posttest (POSTWALK) with months between pretest and posttest (MOBET) as a control variable.

HYP. 1: There is no linear relationship between MOBET and posttest score on the Walker (POSTWALK).

FULL (1) $POSTWALK = 24.9 + 13.0T + 1.7MOBET_c + .1MOBET_e$ $R^2=.0312$

REST (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

$F = 1.79$ with 1/1114 df, $P = .17$

Result is: retain the hypothesis.

HYP. 2: There is no PreK treatment effect.

FULL (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

REST (50) $POSTWALK = 38.1U$ $R^2=.0000$

$F = 32$ with 1/1116 df, $P = .0001$

Result is: reject the hypothesis.

The number of months between pretest and posttest (MOBET) had no linear relation to the total scores on the Walker posttest (TOT2), as shown by Hypothesis 1. The within group correlations were .20 for the control group and .0063 for the PreK. Because of the small n for the control group, a correlation must be quite large to be considered non-zero.

Table 22

Analysis of covariance for a PreK treatment effect on the Walker posttest (POSTWALK) with the pretest (PREWALK) as a control variable.

HYP. 1: There is no linear relationship between PREWALK and posttest score on the Walker (POSTWALK).

FULL (1) $POSTWALK = 20.5 + 9.4T + .5PREWALK_c + .4PREWALK_e$ $R^2=.2692$

REST (2) $POSTWALK = 33.3 + 5.1T$ $R^2=.0280$

F = 184 with 2/1114 df, P = .0001

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTWALK = 20.5 + 9.4T + .5PREWALK_c + .4PREWALK_e$ $R^2=.2692$

REST (3) $POSTWALK = 23.3 + 6.5T + .4PREWALK$ $R^2=.2680$

F = 1.76 with 1/1114 df, P = .19

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of PREWALK.

FULL (3) $POSTWALK = 23.3 + 6.5T + .4PREWALK$ $R^2=.2680$

REST (4) $POSTWALK = 29.7 + .4PREWALK$ $R^2=.2232$

F = 68 with 1/1114 df, P = .0001

Result is: reject the hypothesis.

FINAL MODEL (3): $POSTWALK = 23.3 + 6.5T + .4PREWALK$

Peabody Picture Vocabulary Test

Analysis of covariance was applied to the Peabody Picture Vocabulary Test posttest scores (POSTPEAB) with each of five control variables: AGEPRE, MOED, INCOME, MOBET, and PREPEAB. Data on the control children and PreK children on the Peabody Picture Vocabulary Test are given in Table 23. Simple correlations between variables are given in Table 24. Results of the analysis are presented in Tables 25 to 29.

Table 23
Pretest and Posttest Data on the Peabody Picture Vocabulary Test

Variable Name	Control n=34		PreK n=595		Mean Differences	P
	M_c	SD	M_e	SD		$M_c = M_e$
PREPEAB	47.4	11.6	40.6	12.6	-6.8	.002
POSTPEAB	53.4	10.1	52.2	10.5	-1.2	.496

The control group and the PreK group performed equally well on the Peabody posttest (M_c=53.4, M_e=52.2) but they did not start out at the same level (Table 23). On the pretest, the PreK group was 6.8 points behind the control group (M_c=47.4, M_e=40.6). The simple difference between the groups on the posttest does not consider the pretest difference. Analysis of covariance does consider this difference (Table 25). When the pretest is considered, the difference between the groups favors the PreK by 2.6 points, but the difference is not statistically significant.

In the analysis of covariance (Table 26) where the number of months between pretest and posttest was considered (MOBET), an interaction between MOBET and treatment was identified. This difference is a treatment effect that varies with the number of months between the pretest and posttest as shown in Figure 2. The

regression line for the control group extends only from four months to six months, which is the range of MOBET for the control group. It may be seen in the figure that when there is only four months between the pretest and posttest the control group performed better than the PreK group by about 8 points. However, for children who had six months between pretest and posttest, the PreK group performed better than the control group by about 6 points. These two effects are responsible for the statistically significant interaction with the PreK treatment.

When age at time of the pretest, level of mother's education, and family income are considered there is no difference between the PreK group and the control group (Tables 27-29).

Table 24
Correlation coefficients for the control group and the PreK group for variables used in the analysis of Peabody Picture Vocabulary Test posttest scores.

Control / PreK	AGEPRE	MOED	INCOME	MOBET	PREPEAB	POSTPEAB
AGEPRE	1.00 / 1.00	.06 / -.04	-.02 / .07	-.16 / -.12	.58 / .23	.46 / .15
MOED		1.00 / 1.00	.57 / .20	-.18 / -.01	.33 / .27	.28 / .27
INCOME			1.00 / 1.00	-.35 / .01	.19 / .26	.18 / .18
MOBET				1.00 / 1.00	-.11 / .11	-.32 / .15
PREPEAB					1.00 / 1.00	.67 / .68
POSTPEAB						1.00 / 1.00

Table 25

Analysis of covariance for a PreK treatment effect on the Peabody posttest (POSTPEAB) with pretest (PREPEAB) as a control variable.

HYP. 1: There is no linear relationship between PREPEAB and posttest score on the Peabody (POSTPEAB).

FULL (1) $POSTPEAB = 25.7 + 3.4T + .59PREPEAB_c + .57PREPEAB_e$ $R^2=.4637$

REST (2) $POSTPEAB = 53.4 - 1.3T$ $R^2=.0007$

$F = 270$ with 1/625 df, $P = .0001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTPEAB = 25.7 + 3.4T + .59PREPEAB_c + .57PREPEAB_e$ $R^2=.4637$

REST (3) $POSTPEAB = 26.5 + 2.6T + .57PREPEAB$ $R^2=.4637$

$F = .04$ with 1/625 df, $P = .8486$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of PREPEAB.

FULL (3) $POSTPEAB = 26.5 + 2.6T + .57PREPEAB$ $R^2=.4637$

REST (4) $POSTPEAB = 29.2 + .56PREPEAB$ $R^2=.4606$

$F = 3.55$ with 1/626 df, $P = .0599$

Result is: retain the hypothesis.

FINAL MODEL (4): $POSTPEAB = 29.2 + .56PREPEAB$

Table 26

Analysis of covariance for a PreK treatment effect on the Peabody posttest (POSTPEAB) with months between pretest and posttest (MOBET) as a control variable.

HYP. 1: There is no linear relationship between MOBET and posttest score on the Peabody (POSTPEAB).

FULL (1) $POSTPEAB = 82.6 - 43T - 5.8MOBET_c + 2.5MOBET_e$ $R^2=.027$

REST (2) $POSTPEAB = 53.4 - 1.3T$ $R^2=.001$

$F = 8.5$ with 2/625 df, $P = .003$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTPEAB = 82.6 - 43T - 5.8MOBET_c + 2.5MOBET_e$ $R^2=.027$

REST (3) $POSTPEAB = 42.7 - 1.5T + 2.14MOBET$ $R^2=.017$

$F = 6.3$ with 1/625 df, $P = .0123$

Result is: reject the hypothesis.

FINAL MODEL (1): $POSTPEAB = 82.6 - 43T - 5.8MOBET_c + 2.5MOBET_e$*

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*This final model is plotted as shown in Figure 2.

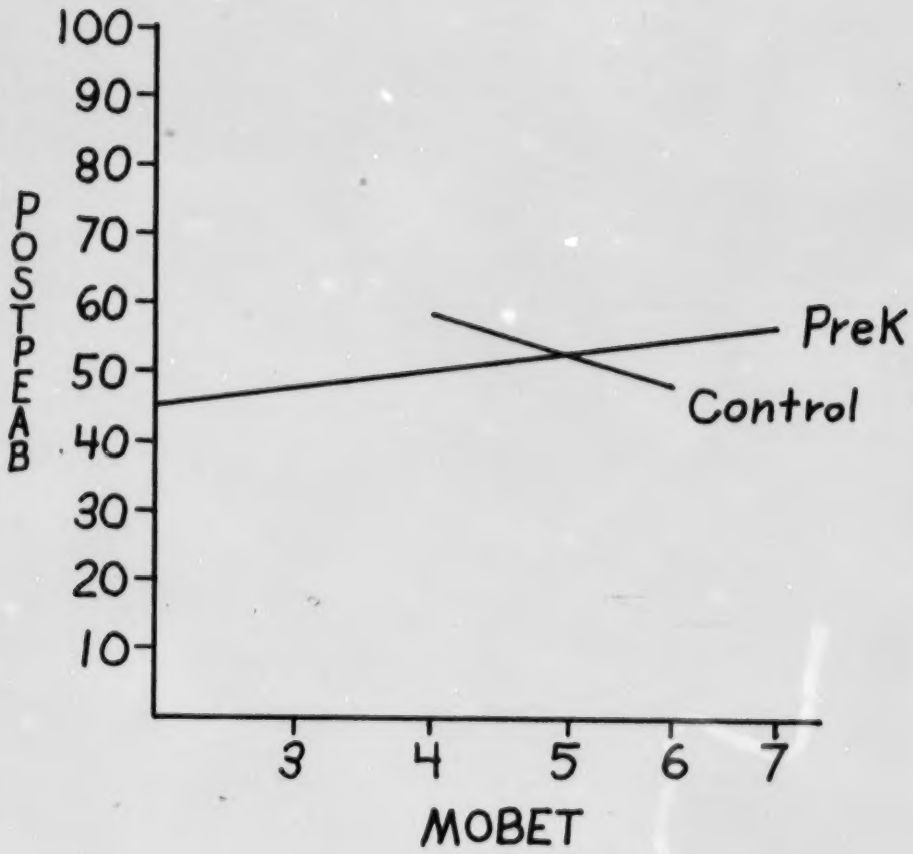

Figure 2.

Relationship between MOBET and POSTPEAB.
(Plot of the Table 26 Final Model)

Table 27

Analysis of covariance for a PreK treatment effect on the Peabody posttest (POSTPEAB) with age at the time of the pretest (AGEPRE) as a control variable.

HYP. 1: There is no linear relationship between AGEPRE and posttest score on the Peabody (POSTPEAB).

FULL (1) $POSTPEAB = -13.7 + 41.7T + 1.22AGEPRE_c + .45AGEPRE_e$ $R^2=.0319$

REST (2) $POSTPEAB = 53.4 - 1.25T$ $R^2=.0007$

$F = 10$ with 2/625 df, $P = .0001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTPEAB = -13.7 + 41.7T + 1.22AGEPRE_c + .45AGEPRE_e$ $R^2=.0319$

REST (3) $POSTPEAB = 26.6 - .94T + .49AGEPRE$ $R^2=.0278$

$F = 2.64$ with 1/625 df, $P = .10$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of AGEPRE.

FULL (3) $POSTPEAB = 26.6 - .94T + .49AGEPRE$ $R^2=.0278$

REST (4) $POSTPEAB = 25.6 + .49AGEPRE$ $R^2=.0274$

$F = .26$ with 1/626 df, $P = .61$

Result is: retain the hypothesis.

FINAL MODEL (4): $POSTPEAB = 25.6 + .49AGEPRE$

Table 28

Analysis of covariance for a PreK treatment effect on the Peabody posttest (POSTPEAB) with mother's education (MOED) as a control variable.

HYP. 1: There is no linear relationship between MOED and posttest score on the Peabody (POSTPEAB).

FULL (1) $POSTPEAB = 36.9 - 1.3T + 1.4MOED_c + 1.4MOED_e$ $R^2=.0720$

REST (2) $POSTPEAB = 53.4 - 1.3T$ $R^2=.0007$

F = 24 with 2/625 df, P = .0001

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTPEAB = 36.9 - 1.3T + 1.4MOED_c + 1.4MOED_e$ $R^2=.0720$

REST (3) $POSTPEAB = 36.1 - .5T + 1.5MOED$ $R^2=.0720$

F = .016 with 1/625 df, P = .899

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of MOED.

FULL (3) $POSTPEAB = 36.1 - .5T + 1.5MOED$ $R^2=.0720$

REST (4) $POSTPEAB = 35.6 + 1.5MOED$ $R^2=.0719$

F = .06 with 1/626 df, P = .8015

Result is: retain the hypothesis.

FINAL MODEL (4): $POSTPEAB = 35.6 + 1.5MOED$

Table 29

Analysis of covariance for a PreK treatment effect on the Peabody posttest (POSTPEAB) with family income (INCOME) as a control variable.

HYP. 1: There is no linear relationship between INCOME and posttest score on the Peabody (POSTPEAB).

FULL (1) $POSTPEAB = 49.8 - 1.58T + .03INCOME_c + .06INCOME_e$ $R^2=.0348$

REST (2) $POSTPEAB = 53.4 - 1.25T$ $R^2=.0007$

$F = 11$ with 2/625 df, $P = .0001$

Result is: reject the hypothesis.

HYP. 3: Regression is the same in both the PreK treatment group and the control group.

FULL (1) $POSTPEAB = 49.8 - 1.58T + .03INCOME_c + .06INCOME_e$ $R^2=.0348$

REST (3) $POSTPEAB = 47.7 + .73T + .05INCOME$ $R^2=.0341$

$F = .44$ with 1/625 df, $P = .5078$

Result is: retain the hypothesis.

HYP. 4: There is no difference between the PreK treatment group and the control group in the presence of INCOME.

FULL (3) $POSTPEAB = 49.8 - 1.58T + .05INCOME$ $R^2=.0341$

REST (4) $POSTPEAB = 48.4 + .05INCOME$ $R^2=.0339$

$F = .15$ with 1/626 df, $P = .6970$

Result is: retain the hypothesis.

FINAL MODEL (4): $POSTPEAB = 48.4 + .05INCOME$

SUMMARY AND CONCLUSIONS

Analyses of covariance were carried out on three measures of cognitive development with one of five variables used as covariate in each analysis. A significant positive effect of the prekindergarten program was found for two of the measures, the Cooperative Preschool Inventory and the Walker Readiness Test. With one exception, the PreK effect was significant over all levels of the control variables; the PreK effect on Walker scores was greater for children whose mothers had less education.

Analyses of covariance of Peabody Picture Vocabulary Test scores did not show a significant PreK effect, even in the presence of the control variables. A significant interaction was found between the number of months between pretest and posttest and the treatment: among children who had only four months between testing, the control group performed better than the PreK group; among children who had six months between testing, the reverse was found.

These analyses provide evidence that the Experimental Prekindergarten Program has a positive effect on certain aspects of cognitive development. Future analyses will be designed to corroborate this conclusion, to reveal more about the nature of the effect, and to study the effect on children over an extended period.

CRITIQUE

A number of problems exist in the analyses reported here. The "pretesting" did not begin until the middle of November, with the bulk of the pretesting taking place between that time and the Christmas break in December. For that reason, the pretest-to-posttest interval was shorter than it will be for succeeding waves. The

short interval may reduce the likelihood of obtaining a true picture of the prekindergarten effect.

Loss of children from the study because they moved out of participating districts reduced the size of both the PreK group and the control group. This will become a serious problem as the study continues. The sampling plan adopted for the study calls for replacement of lost children from the pool of children tested at the beginning of prekindergarten. However, in seven districts all children are being studied so that no replacements are available for them. In addition, present plans call for random replacement of lost children within districts; this could result in an unrepresentative sample since the lost children may not be a random group. A comparison of the sample studied here and the PreK population indicates that the sample is representative on key dimensions. An additional problem stems from the fact that the plan for replacements can keep the size of the sample large but many children in the sample will not have data for each testing time; the subsample for which complete longitudinal data are available will be smaller.

The control group is not comparable to the PreK group in ethnic distribution. It is comparable on other dimensions, including distribution by sex, father's occupation, mother's occupation, and proportion of English-speaking versus non-English-speaking children. Two other factors—mother's education and family income—were used as control variables in the analyses of covariance.

The small size of the control group relative to the PreK group raises a question about the appropriateness of the F-statistic as the test of significance. Additional study is being given to identify more appropriate procedures. The problem may be reduced by acquiring a substantially larger control group to be

used in studying these children in kindergarten. (That solution raises its own problems, since no data will be available on those children before they entered kindergarten.)

Problems in administering the Peabody Picture Vocabulary Test were identified when analysis of data began. As a result, data were dropped for a number of children for whom correct Peabody scores could not be obtained. In addition, a number of errors were apparent in results for non-English-speaking children (to whom the test was to be administered in English), resulting in a decision to analyze results only of English-speaking children in the PreK group and the control group.

Finally, this report describes results obtained with three cognitive measures. These measures sample only a portion of the total development of children. It is not presented as a complete picture of the impact of the Experimental Prekindergarten Program on the cognitive and noncognitive development of children.

FUTURE ANALYSES

Analyses under way or planned will pursue the problem of unequal sizes of the PreK group and the control group. Other potential control variables will be investigated. Subscores of the three criterion measures used in these analyses will be studied to obtain a more accurate picture of the effects of prekindergarten on different aspects of cognitive development. School factors will be studied to determine what aspects of the program account for different effects. Finally, a second wave of children will be studied to verify the findings presented in this report.

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